The
Electric Power Club

Instructions For Care and Operation of Transformers

PUBLICATIONS

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The Electric Power Club

Instructions For Care and Operation of Transformers

Part I

Power Transformers

Part II

Distribution Transformers

Fourth Edition
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The Electric Power Club
B. F. Keith Building
Cleveland, Ohio, U. S. A.

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Foreword

THE ELECTRIC POWER CLUB is an association of manufacturers of electric power apparatus and control equipment, first organized in 1908 as The American Association of Electric Motor Manufacturers, for the improvement in design and construction, the standardization, and the increased distribution of such products.

The standards and practices adopted by The Electric Power Club during the past eighteen years are published in The Electric Power Club Handbook of Standards—Electric Power Apparatus. The transformer standards are also published in a separate publication by the Transformer Section of the Club, which also issues this book of instructions for the care and operation of both power and distribution transformers.

The member companies composing the Transformer Section of The Electric Power Club are listed on the inside back cover. These companies manufacture the great preponderance of the distribution and power transformers produced in the United States.

This booklet is a reference work of practical information containing instructions for the proper care and operation of both power and distribution transformers, and is supplementary to the standards of manufacture, performance and test published in the book of transformer standards. Representing, as it does, the recommendations of the Transformer Section of The Electric Power Club, this booklet is found most useful by electrical engineers, superintendents of distribution, line foremen, electricians, operators, students and others responsible for the operation and maintenance of transformers.

Standards applying to the manufacture, performance and test of other electric power apparatus and control equipment, also rules for their proper installation, operation and care, are given in other Electric Power Club publications, a list of which appears on the inside front cover. Information regarding standards and practices not covered in any of the Club's publications may be secured by addressing The Electric Power Club, B. F. Keith Building, Cleveland, Ohio, U. S. A.

PART I

Instruction for Care and Operation of Power Transformers

(All sizes above 200 Kv-a.)

THE successful operation of transformers is dependent upon proper installation and operation as well as upon proper design and manufacture. While a transformer requires less care than almost any other type of electrical apparatus, neglect of certain fundamental requirements may lead to serious trouble, if not to the loss of the transformer. For this reason, a wide distribution of information in regard to the proper care of transformers is important, and these brief instructions are published for that purpose.

Instructions for Care and Operation of Power Transformers

These instructions apply to all power transformers and to all distribution transformers above 100 Kv-a. in capacity or for operation on 22000 volts or higher.

Location

Accessibility, ventilation and ease of inspection should be given careful consideration in locating transformers.

Water-Cooled Transformers depend almost entirely upon the flow of water through the cooling coils for carrying away heat, so that the temperature of the surrounding air has little effect upon that of the transformers. For this reason air circulation is of minor importance and water-cooled transformers may be located in any convenient place without regard to ventilation.

Self-Cooled Transformers depend entirely upon the surrounding air for carrying away their heat. For this reason care must be taken to provide adequate ventilation. For indoor installation the room in which the transformers are placed must be well ventilated so that heated air can escape readily and be replaced by cool air from outside. The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. In general, about 20 sq. ft. of opening should be provided for each 1000 Kv-a. of transformer capacity. Air inlets should be provided with the same total area as the outlets. If the transformer will be required to operate for considerable periods at continuous full load, the areas of the openings should be increased to about 40 sq. ft. per 1000 Kv-a. of transformer capacity. Self-cooled transformers of the indoor type must be so located that water cannot fall on the tanks or rain blow upon them.

Self-Cooled Transformers should always be separated from one another and from adjacent walls, partitions, etc., in order to permit free circulation about the tanks. This separation should not be less than 24 in. to 36 in., depending on size.

Storage

When a transformer can be set up immediately in its permanent location and filled with oil, it is advisable to do so, even though it will not be put into service for some time. If this is not convenient it should be stored in a dry place, having no rapid or radical temperature changes, and if possible, immersed in dry transformer oil. The transformer should not be stored or operated in the presence of corrosive gases such as chlorine, etc. If an indoor transformer is stored *OUTDOORS*, it should be thoroughly covered to keep out rain.

Handling

When lifting a transformer, the lifting cables must be held apart by a spreader to avoid bending the lifting studs or other parts of the structure.

Where a transformer cannot be handled by a crane, it may be skidded or moved on rollers, but care must be taken not to damage the base, or tip it over. A transformer should never be lifted or moved by placing jacks or tackle under the drain valve, cooling coil outlets, radiator connections or other attachments. When rollers are used under large transformers, skids must be used to distribute the stress over the base.

When working about a transformer particular care must be taken in handling all tools and other loose articles, since anything metallic dropped among the windings and allowed to remain there may cause a breakdown.

Installation

Transformers are in first class operating condition when shipped by the manufacturer, i. e., they have been thoroughly tested for defects and are perfectly dry.

When received, examination should be made before removing from cars and if any injury is evident or any indication of rough handling is visible, railroad claim should be filed at once and the manufacturer notified.

Moisture may condense on any metal if the metal is colder than the air, and if present, it lowers the dielectric strength

and may cause a failure of the transformer. Therefore, if transformers or oil drums are brought into a room warmer than they are, they should be allowed to stand before opening until there is no condensation on the outside and they are thoroughly dry.

Before being set up, a transformer should be inspected for breakage, injury or misplacement of parts during shipment, and thoroughly examined for moisture. In addition all accessible nuts, bolts and studs should be tightened.

If transformers are water cooled, the cooling coils should be tested for leaks at a pressure of 80 to 100 lbs. per sq. in. Water, oil or preferably air, may be used in the coil for obtaining the pressure. The coil must be outside the tank, i. e., away from the coil insulation if water is used for the pressure test. When pressure is obtained, the supply should be disconnected and after 1 hour it should be determined whether any fall in pressure is due to a leak in the coil, or is in the fittings at the ends of the coil.

Transformers Shipped Filled With Oil

Each transformer shipped filled with oil should be inspected to see whether there is any condition indicating the entrance of moisture during shipment.

If the transformer is received in damaged condition, so that water or other foreign material has had a chance to enter the tank, the transformer should be emptied of oil and treated as though not shipped in oil, and in no case may drying be omitted.

In all cases samples of oil should be taken from the bottom and tested. The dielectric strength of the oil when shipped is at least 22 Kv. between 1 in. disks spaced 0.1 in. apart. A new transformer should not be put into service with oil which tests below this value.

Transformers Shipped Assembled Without Oil

Each transformer shipped assembled but not filled with oil should be carefully inspected for damage in shipment. A thorough inspection can only be made by removing core and coils from the tank. All dirt should be wiped off and parts examined for breakage or other injuries. All conductors and terminals should be examined to check their proper condition and position. The coil and core clamps should be tightened if necessary.

The tank should be inspected and, if necessary, cleaned.

When a transformer is shipped assembled but not filled with oil, moisture may be absorbed during transportation. For this reason it is good practice to dry out all such transformers, especially transformers above 7500 volts, before being put into service.

Transformers Shipped Disassembled

Only very large transformers are shipped in this way, and special instructions covering features incident to this method of shipping are supplied by the manufacturer. These instructions should be carefully followed.

Drying Core and Coils

There are a number of approved methods of drying out transformer core and coils, any one of which will be satisfactory if carefully performed. However, too much stress cannot be laid upon the fact that if carelessly or improperly performed, great damage may result to the transformer insulation through over-heating.

The methods in use may be broadly divided into two classes:

1. Drying with the core and coils in the tank with oil.
2. Drying with the oil removed. The core and coils may or may not be removed from the tank.

Under the first class, the moisture is driven off by sending current through the winding while immersed in oil, with the top of the tank open to the air, or some other arrangement made for adequate ventilation. This may be done by:

(a) The short circuit method (to be used if the transformer is new or has been out of service without oil any length of time).

(b) The normal operation method (to be used if the transformer is already in service but shows moisture condensation and the transformer cannot be shut down to apply the short circuit method).

Short Circuit Method With Oil

This method consists in heating the windings and oil up to a high temperature for a limited time under short circuit with a partial load on the windings, the high oil temperature being obtained by blanketing

the tank (or reducing the flow of water for water-cooled transformers). When a transformer is short circuited in this manner only a fraction of the normal voltage should be applied to one winding. In using this method, if the load does not exceed one-half or three-quarters full load, the winding temperature is not greatly in excess of the maximum or top oil temperature, so that high oil temperatures are safe without resulting in any deterioration of the insulation from local over-heating. With good ventilation, the moisture, as it is driven off in the form of vapor will escape to the outside atmosphere and no condensation of moisture will take place on the underside of the cover or elsewhere in the tank.

The following table shows the short circuit current in per cent of full load current which may be used for this method of drying transformers, with the corresponding maximum allowable top oil temperature in degrees centigrade. Less than 5 per cent of normal voltage will usually be required to circulate the current in the windings.

Short Circuit Amps. in Percent of full Load		Maximum Top Oil Temperature
Self-Cooled Transformers	Water-Cooled Transformers	
50	50	85 deg. C.
75	60	80 deg. C.
85	75	75 deg. C.

These temperature limits and loads must be strictly adhered to in order to obtain the desired results without danger to the transformers.

It should be noted that the higher allowable temperatures go with the smaller loads, that is, more blanketing or less water will be required for the smaller loads than for the higher, in order to bring the oil temperature up to the point shown in the table.

Ventilation—During the drying run, additional ventilation to that ordinarily provided should be maintained by slightly raising the manhole cover and protecting the opening from the weather. The entire cover should be lagged with heat insulating material to prevent condensation of moisture within.

When to Discontinue Drying—Drying should be continued until oil from the top and bottom of the tank tests 22 Kv. or higher between 1.0 in. square edge discs spaced 0.1 in. for seven consecutive tests taken 4 hrs. apart with the oil maintained at maximum temperature for the load held and without filtering. All ventilating openings should then be closed and the transformer kept at the same temperature for another 24 hrs. without filtering the oil and as before the oil should be tested at 4 hr. intervals. A decrease in the dielectric strength of the oil indicates that moisture is still passing from the transformer into the oil and drying should be continued.

Unless constant or increasing dielectric strength as shown by these tests indicates that drying is completed, the ventilators should be opened, the oil filtered and the drying process continued.

After the short circuit run is discontinued, the transformer should be operated for 24 hrs. at approximately two-thirds voltage and at the same high temperature, making similar tests of oil samples and filtering the oil if necessary. After satisfactory two-thirds voltage test, full voltage should be applied for 24 hrs. and the same tests repeated. Water-cooled transformers may require some water to hold the top oil temperature within the 85 deg. C. limit during this test.

Normal Operation Method

This method consists in providing ventilation in the cover, as explained above, and blowing air across the top oil, say by a desk fan, while the transformer is under normal operation.

The manhole cover should be inspected frequently and the oil temperature raised by blanketing the tank or increasing the load. If condensation appears on the under side of the manhole cover, the oil temperature should be reduced and the run continued until the moisture disappears, when the temperature should again be raised.

The following table shows the highest permissible load current for maximum top oil temperatures of 70, 75 and 85 deg. C.:

Load Amps. in Percent of full Load		Maximum Top Oil Temperature
Self-Cooled Transformers	Water-Cooled Transformers	
50	50	85 deg. C.
85	75	75 deg. C.
100	85	70 deg. C.

The operation should be continued for 3 days at maximum temperature; then if no condensation occurs, the drying may be discontinued as outlined above in the paragraph "When to Discontinue Drying".

Typical of the second class, i. e., drying with the oil removed, are the three following methods:

A—By internal heat.
B—By external heat.
C—By internal and external heat.

(A) By Internal Heat—For this method alternating current is required. The

transformer should be placed in its tank without the oil and the cover left off to allow free circulation of air. Either winding can be short circuited and sufficient voltage impressed across the other winding to circulate enough current through the coils to maintain the temperature at from 75 deg. C. to 80 deg. C. About one-fifth of normal full-rated current is generally sufficient to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers, but will generally be approximately ½ of 1 per cent to 1½ per cent of normal voltage, at normal frequency.

The end terminals of the winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat in series with the exciting winding.

This method of drying out is superficial and slow and should only be used with small transformers, and then only when local conditions prohibit the use of one of the other methods.

(B) By External Heat—The transformer should be placed in a wooden box with holes in the top and near the bottom to allow air circulation. The clearance between the sides of the transformer and the box should be small so that most of the heated air will pass up through the ventilating ducts among the coils and not around the sides. The heat should be applied at the bottom of the box.

The best way to obtain the heat is from grid resistors, using either alternating or direct current. The temperature limits are the same as for Method A. The transformer must be carefully protected against direct radiation from the heaters. Care must also be taken to see that there is no inflammable material near the heaters, and to this end it is advisable to completely line the wooden box with asbestos.

Instead of placing the heater inside the box containing the transformer, it may be placed outside and the heat carried into the bottom of the box through a suitable pipe. Where this plan is followed, the heat may be generated by the direct combustion of gas, coal or wood, provided that none of the products of combustion be allowed to enter the box containing the transformer. Heating by combustion is not advocated except when electric current is not available.

This method, while effective, requires a much longer time than Method C.

(C) By Internal and External Heat—This is a combination of Methods A and B. The transformer should be placed in a box and external heat applied as in B and current circulated through the windings as in A. The current should, of course, be considerably less than when no external heat is applied.

This method is used occasionally where direct current only is available, a certain amount of current being passed through the high voltage winding only, as the cross sectional area of the low voltage conductor is generally too large for it to be heated with an economical amount of direct current. The use of direct current for drying out is not recommended except where alternating current cannot be obtained. When this method of drying is used, the temperature should be measured by the increase in resistance method.

Method C is quicker than either A or B and has the great advantage that the insulation is heated much more uniformly.

Time Required for Drying—There is no definite length of time for drying. One to 3 weeks will generally be required, depending upon the condition of the transformer, the size, the voltage and the method of drying used.

Insulation Resistance—The measurement or determination of insulation resistance is of value in determining the course of drying, only when the transformer is without oil. If the initial insulation resistance be measured at ordinary temperatures, it may be high although the insulation is not dry, but as the transformer is heated up, it will drop rapidly.

As the drying proceeds at a constant temperature, the insulation resistance will generally increase gradually until towards the end of the drying period when the increase will become more rapid. Sometimes the resistance will rise and fall through a short range one or more times before reaching a steady high point. This is caused by moisture in the interior parts of the insulation working its way out through the outer portions which were dried at first.

As the temperature varies, the insulation resistance also varies greatly, therefore the temperature should be kept nearly constant and the resistance measurements should all be taken at as nearly the same temperature as possible. The insulation resistance in megohms varies inversely with the temperature and for a 10 deg. C. change of temperature, the megohms change by a ratio of 2:1. Measurements should be taken every 2 hours during the drying period.

Resistance Curve—A curve of the insulation resistance measurements should be plotted with time as abscissae and resistance as ordinates. By observation, the knee of the

curve (i. e., the point where the insulation resistance begins to increase more rapidly) can be determined and the run should continue until the resistance is constant for 12 hours.

Precautions to be Observed in Drying Without Oil—As the drying temperature approaches the point where fibrous materials deteriorate, great care must be taken to see that there are no points where the temperature exceeds 85 deg. C. Several thermometers should be used and they should be placed well in among the coils near the top and screened from air currents. Ventilating ducts offer particularly good places in which to place some of the thermometers. As the temperature rises rapidly at first, the thermometers must be read at intervals of about ½ hour. In order to keep the transformer at a constant temperature for insulation resistance measurements, 1 thermometer should be placed where it can be read without removing it or changing its position. The other thermometers should be shifted about until the hottest points are found, and should remain at these points throughout the drying period. Wherever possible, the temperature should be checked by the increase in resistance method.

Caution—It is well to have a chemical fire extinguished or a supply of sand at hand for use in case of necessity.

It is not safe to attempt the drying out of transformers without giving them constant attention.

Sampling and Testing of Oil

The sample container should be a large mouth glass bottle. All bottles should be cleaned and dried with gasoline before being used. A cork stopper should be used.

The sample for dielectric tests should be at least 16 oz., and if other tests are to be made, 1 quart (32 oz.).

Test samples should be taken only after the oil has settled for some time, varying from 8 hours for a barrel to several days for a large transformer. Cold oil is much slower in settling and may hardly settle at all. Oil samples from the transformer should be taken from the oil sampling valve at the bottom of the tank. Oil samples from a barrel should be taken from the bottom of the drum. A brass or glass "thief" can be conveniently used for this purpose. The same method should be used for cleaning the "thief" as is used for cleaning the container.

When drawing samples of oil from the bottom of the transformer or large tank, sufficient oil must first be drawn off to make sure that the sample will be comprised of oil from the bottom of the container, and not from the oil stored in the sampling pipe. A glass receptacle is desirable so that if water is present, it may be readily observed. If water is found, an investigation of the cause should be made and a remedy applied. If water is not present in sufficient quantity to settle out, the oil may still contain considerable moisture in a suspended state. It should, therefore, be tested for dielectric strength.

Testing

For testing oil for dielectric strength some standard device for oil testing should be used. The standard oil testing spark gap has disc terminals 1 in. in diameter spaced 0.1 in. apart. The testing cup should be cleaned thoroughly to remove any particles of cotton fibre, and rinsed out with a portion of the oil to be tested.

The spark gap receptacle should be nearly filled with oil and allowed to stand for a few minutes to give bubbles time to escape before making the test.

The rate of increase in voltage should be about 3000 volts per second. Five breakdowns should be made on each filling and then the receptacle emptied and refilled with fresh oil from the original sample. The average voltage of 15 tests (5 tests on each of 3 fillings) is usually taken as the dielectric strength of the oil. It is recommended that the test be continued until the mean of the averages of at least 3 fillings is consistent.

The dielectric strength of oil when shipped is at least 22 Kv. tested in the standard gap. If the dielectric strength of the oil in a transformer in service, tests at less than 16,500 volts, it should be filtered. New oil of less than the standard dielectric strength should not be put in a transformer.

Drying Oil and Filling Transformer

In removing moisture from transformer oil, it is preferable to filter from one tank and discharge into another, although if necessary it may be drawn from the bottom of a tank and discharged at the top. When there is much water in the oil, it should be allowed to settle, then drawn off and treated separately.

Filling Transformers

Before the transformer is filled with oil all accessories, such as valves, gauges, thermometers, plugs, etc., must be fitted to the

transformer and made oil tight. The threads should be filled with shellac before putting them in place. The transformers must be thoroughly cleaned.

Metal hose must be used instead of rubber hose, because oil dissolves the sulphur found in rubber, and may cause trouble by the sulphur attacking the copper.

The oil used should be clean, dry oil of the grade recommended by the manufacturer.

The use of a filter press is recommended and if one is not available some precaution should be taken to strain the oil before putting it in the transformer.

After filling the transformer, the oil should be allowed to settle at least 12 hours and then samples taken from the bottom should be again tested before voltage is applied to the transformer.

It is very important that the surfaces of the oil when cold (25 deg. C.) be at the oil level indicated by the mark on the oil gauge. When the transformer is not in service, the oil level must never be allowed to fall to a point where it does not show in the gauge. When it is necessary to replenish the oil, care must be taken to see that no moisture finds its way into the tank. As the oil heats up with the transformer under load, it will expand and rise to a higher level.

First Time in Service

When the voltage is first applied to the transformer it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be discovered before damage results. After full voltage has been applied successfully, the transformer should preferably be operated in that way for a short period without load. It should be kept under observation during this time and also during the first few hours that it delivers load. After 4 or 5 days' service it is advisable to test the oil again for moisture.

Water Circulation

If the transformer is water-cooled, the main water valve should be opened as soon as the oil temperature reaches 45 deg. C. If there are 2 or more sets of cooling coils in parallel, the valves of all sections should be adjusted for equal rates of flow. This can be estimated by feeling the weight of the discharge streams from the different sections. It can be determined best, however, by noting the difference in temperature between ingoing and outgoing water from each section. A careful measure should be taken of the total amount of water flowing through all sections and the total rate of flow adjusted to that called for.

Care

The idea that a transformer in service needs no attention may lead to serious results. Careful inspection is essential, and the directions given in this section should be followed.

In spite of all precautions, moisture may be absorbed by the transformer; and during the first few days of operation it is well to inspect the inside of the manhole cover for moisture. If sufficient moisture has condensed to drip from the cover, the transformer should be taken out of service and dried. The oil should be tested and dried if necessary.

Oil

Samples of oil from all transformers should be drawn and tested at least once every 6 months.

During the first month of service of transformers having a potential of 40,000 volts or over, samples of oil should be drawn each week from the bottom of the tank and tested.

If at any time the oil should test below 16,500 volts, it should be filtered.

Inspection

No matter how satisfactory the operation of a transformer may be, it should be taken out of service and thoroughly inspected at least once a year. The inside of the cover and the tank above the oil should be regularly inspected to see that they are clean, dry and free from moisture and that the thermometer bulb is clean. If an appreciable amount of dirt or sediment is found inside the case it is best to take out the transformer and remove the oil from the tank. The transformer and the tank should then be cleaned thoroughly and the oil filtered and tested. In cleaning, only dry cloths or waste should be used. Care should be taken to see that all nuts are tight and all parts in their proper places. If the transformer is water-cooled, the cooling coils should be cleaned thoroughly. The transformer and the oil should be replaced in the tank and when the cover is put on, all cracks and openings closed tightly.

In the case of water-cooled transformers, the rate of flow should be checked from time to time and if it is found to have diminished the cause should be looked for and remedied. The most frequent cause of clogging of cooling coils is the presence of

air in the water, resulting in the formation of a scaly oxide.

Removing Scale From Cooling Coils

Scale and sediment can be removed from a cooling coil without removing the coil from the tank. Both inlet and outlet pipes should be disconnected from the water system and temporarily piped to a point a number of feet away from the transformer, where the coil can be filled and emptied safely. Especial care must be taken to prevent any acid, dirt or water from getting into the transformer.

All the water should be blown or syphoned from the cooling coils which should be then filled with a solution of hydrochloric (muriatic) acid, specific gravity 1.10. (Equal parts of commercially pure concentrated hydrochloric acid and water will give this specific gravity.)

It may be found necessary to force this solution into the cooling coils. When this is done one end of the coil should be partially restricted, so that the solution will not be wasted when the coil is full. After the solution has stood in the coil about an hour, the coil should be flushed out thoroughly with clean water. If all the scale is not removed the first time, the operation should be repeated until the coil is clean, using new solution each time. The number of times it is necessary to repeat the process will depend on the condition of the coil though ordinarily 1 or 2 fillings will be sufficient.

As the chemical action which takes place may be very violent and may often force acid, sediment, etc., from both ends of the coil, it is well, therefore, to leave both ends partially open to prevent abnormal pressure.

Idle Cooling Coils

When a water-cooled transformer is idle and exposed to freezing temperatures the water must be blown out of the cooling coil. In addition to blowing out the water the cooling coils should be dried by forcing heated air through them. If not convenient to do this the coil should be filled with transformer oil.

Operation

An artificially cooled transformer should not be run continuously, even at no-load, without the cooling medium. Therefore, it is essential to maintain a proper circulation in the cooling system.

If the water circulation is stopped for any reason, the load should be immediately reduced as much as possible and close watch kept of the temperature of the transformer. When the oil at the top of the tank reaches 80 deg. C. the transformer must be cut out of service at once. This temperature should be recognized as an absolute limit and must not be exceeded. It should be held only during an emergency period of short duration.

Nearly all cooling water will in time cause scale or sediment to form in the cooling coil. The time required to clog up the cooling coils depends on the nature and amount of foreign matter in the water. The clogging materially decreases the efficiency of the coil and is indicated by a high oil temperature and a decreased flow of water, load condition and water pressure remaining the same.

Temperature

Thermometers should be read daily or more often. If the indicated oil temperature is 80 deg. C. or over for a self-cooled unit or 65 deg. C. or over for a water-cooled unit, the transformer must be cut out of service at once and the cause of the excessive heating investigated. Should a transformer remain in service any length of time under this condition, it may be seriously damaged.

Regardless of oil temperature as indicated by thermometers, the transformer must not be operated at overloads not stipulated by the specifications or contract. When the contact specifies an overload, a water-cooled transformer operated at such overload should have the amount of water increased in proportion to the load. On account of the increased amount of water during overload the temperature of the oil will not rise as fast as the temperature of the windings and any of the causes leading to excessive heating will have more pronounced effect under these conditions. Therefore, the transformer during overload should be watched with especial care to see that the oil temperature is kept well below the temperature limits specified.

Moisture may get into a transformer due to the fact that as oil is heated and cooled it expands and contracts and therefore air is expelled from and enters the transformer. If the air which enters the transformer is at the same time cooled off by contact with cover to below its dew point moisture will condense.

It is therefore good practice to operate transformers at several degrees above air temperatures at all times. This will largely prevent condensation.

PART II

Instructions for Care and Operation of Distribution Transformers

(Sizes of 200 Kv-a. and below)

THE instructions for the care and operation of power transformers are somewhat too elaborate to be followed in connection with the operation of distribution transformers of small capacities which are used in very large quantities. The following simplified rules are suggested in connection with the care and operation of these smaller capacity distribution transformers.

Exceptions—*It is recommended that for distribution transformers of voltages of 22000 volts and above and for capacities above 100 Kv-a., such for instance as are usually mounted on a platform or in other localities where they are readily accessible for inspection, the same rules be followed as are given in Part I for the care and operation of power transformers.*

Instructions for Care and Operation of Distribution Transformers

***Exceptions**—The instructions for power transformers given in Part I should be followed for all distribution transformers above 100 Kv-a. in capacity or for operation on 22000 volts or higher.*

Location

Accessibility, ventilation and ease of inspection should be given careful consideration in locating transformers.

Self-Cooled Transformers depend entirely upon the surrounding air for carrying away their heat. For this reason, care must be taken to provide adequate ventilation. For indoor installation the room in which the distribution transformers are placed must be well ventilated so that heated air can escape readily and be replaced by cool air from outside.

Distribution transformers should always be separated from one another and from adjacent walls, partitions, etc., in order to permit free circulation about the tanks. This separation should not be less than 12 in.

Storage

When distribution transformers can be set up immediately in permanent locations and filled with oil, it is advisable to do so even though they will not be put into service for some time. If this is not convenient they should be stored in a dry place having no rapid or radical temperature changes, and if possible, immersed in dry transformer oil. Distribution transformers should not be stored or operated in the presence of corrosive gases, such as chlorine, etc.

Handling

Where a distribution transformer cannot be handled by a crane, it may be skidded or moved on rollers, but care must be taken not to damage the base or tip it over. A distribution transformer should never be lifted or moved by placing jacks or tackle under the drain valve or other attachments and must not be moved by taking hold of the leads. When rollers are used under large distribution transformers, skids must be used to distribute the stress over the base.

When working about a transformer particular care must be taken in handling all tools and other loose articles, since anything metallic dropped among the windings and allowed to remain there may cause a breakdown.

Inspection Preliminary to Installation

Transformers are in first class operating condition when shipped by the manufacturer, i. e., they have been thoroughly tested for defects and are perfectly dry.

When received, examination should be made before removing from cars, and if any injury is evident or any indication of rough handling is visible, railroad claim should be filed at once and the manufacturer notified.

Moisture may condense on any material if the metal is colder than the air, and if present, it lowers the insulation properties and may cause failure of transformer. Therefore, if transformers or oil drums are brought into a room warmer than they are, they should be allowed to stand before opening until there is no condensation on the outside and they are thoroughly dry.

Before being set up, a transformer should be inspected for breakage, injury or misplacement of parts during shipment, and thoroughly examined for moisture. All accessible nuts, bolts and studs should be tightened.

Pole Mounting—Convenient lugs or eye bolts are provided on the side of the case to which the rope lifting the transformer may be attached. It will be found convenient to fasten the hanger irons to the case before the transformer is raised to the cross-arm. The transformer can then be raised up to and slightly above the cross-arm and the hooks on the hanger-irons made to engage the cross-arm by lowering the transformer.

The majority of distribution transformers are shipped in their tanks without oil. Due to the fact that the windings of these transformers are usually impregnated with a special compound, no drying out of these transformers is necessary unless the presence of moisture is readily apparent from visual inspection. Under such circumstances, drying out should be resorted to; otherwise, it is unnecessary. If distribution transformers are shipped in their tanks filled with oil, the oil should be tested for moisture and if moisture is present the transformers should be dried out. For methods of drying out transformers refer to instructions for the care and operation of power transformers in Part I.

Filling Transformers

Metal hose must be used instead of rubber hose, because oil dissolves the sulphur found in rubber and may cause trouble by the sulphur attacking the copper.

Pole-mounted transformers may be filled with oil, either before or after mounting, as desired. It is sometimes necessary to add oil a short time after the transformer has been installed, due to the fact that the insulation will absorb a certain amount of oil. It may be found necessary to replenish the oil from time to time during actual operation in order that the normal oil level be kept constant. When the transformer oil is replenished care should be taken that no moisture finds its way inside the case.

The oil used should be of the grade recommended by the manufacturer, as the successful operation of the transformer depends upon it to a great extent.

Replacing the Cover—Great care should be exercised in putting on the cover. If the gasket is not properly in place or the cover not securely bolted to the case, moisture in the form of snow or rain may be driven into the transformer tank.

It is very important that the surface of the oil when cold (25 deg. C.) be at the oil level indicated on the inside of the tank or the oil gauge.

Care of Transformers in Service

The following practice is recommended for the care of pole-mounted distribution transformers in service:

(1) The oil level should be inspected once every year and enough oil added to bring the level up to the mark inside the tank or on the oil gauge.

(2) Every 3 years the oil should be removed from the tank and replaced with clean, dry oil.

(3) A periodic check of the load should be made to make sure a transformer is not being overloaded.

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